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## Bulletin No. 168 - Relative Resistance of Various Crops ot Alkali

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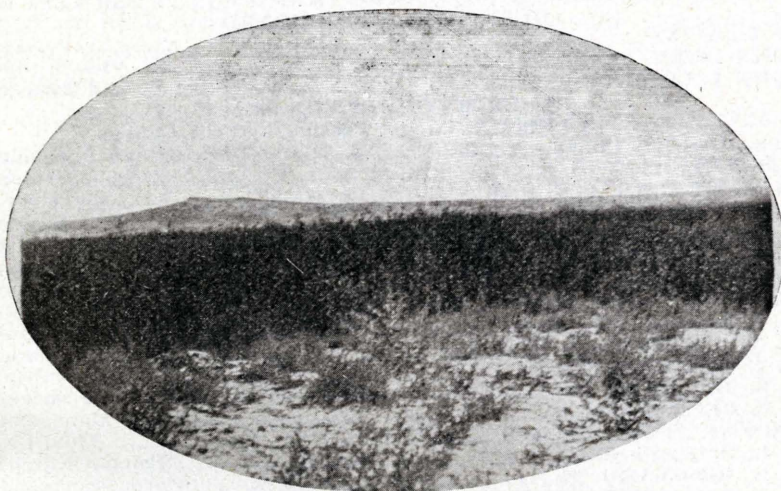
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# RELATIVE RESISTANCE OF VARIOUS CROPS TO ALKALI

By

F. S. HARRIS and D. W. PITTMAN



BULLETIN NO. 168

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Utah Agricultural College  
EXPERIMENT STATION

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Logan, Utah

July, 1919

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# RELATIVE RESISTANCE OF VARIOUS CROPS TO ALKALI

By

F. S. HARRIS and D. W. PITTMAN

Plants show considerable variation in their resistance to soil alkali. Some varieties of native vegetation grow only where the salt content of the soil is high. Most of the cultivated plants, on the other hand, are injured very decidedly by the presence of large quantities of soluble salts. To this rule there are a few exceptions such as the date palm.

In most of the arid parts of the world there are sections where the presence of alkali is the chief limiting factor in crop growth. Millions of acres of land are in the border zone between complete freedom from alkali and a concentration that would prohibit crop production. Crops must be found for this land. Good judgment directs against the use of crops that are sensitive; the yield of resistant crops is reduced much less by the presence of salt than that of the sensitive ones. It becomes important, therefore, to determine the relative resistance of the various crops in order that a more intelligent selection may be made.

The experiments reported in this bulletin were undertaken to throw some light on the subject as to the relative germination and early growth of different crops in alkali soil. Different varieties of the same crop as well as different crops were tested. A great deal of work has been done on this subject by other investigators, but space in the present publication does not permit this work to be reviewed.

## EXPERIMENTAL METHODS

The experiments herein reported were conducted during the summers of 1917 and 1918. Greenville loam soil, which is high in lime, was used in each case. An equivalent of 200 grams of dry soil was made up to 20 per cent moisture on the basis of dry soil, the salt being added in solution.

The soil was then placed in glass tumblers and ten seeds planted in each tumbler. All treatments were made up in triplicate.

The plants were allowed to grow for three weeks when they were harvested and the dry weight determined. The number of plants that had come up in each case was also recorded as well as the average time required to germinate.



Sodium chloride, sodium carbonate, and sodium sulfate were used in each case in the following concentrations expressed in parts of salt per million parts of dry soil:

Number	Sodium Chloride	Sodium Carbonate	Sodium Sulfate
1	none	none	none
2	333 p.p.m.	666 p.p.m.	1,000 p.p.m.
3	666 p.p.m.	1,333 p.p.m.	2,000 p.p.m.
4	1,000 p.p.m.	2,000 p.p.m.	3,000 p.p.m.
5	1,500 p.p.m.	3,000 p.p.m.	4,500 p.p.m.
6	2,000 p.p.m.	4,000 p.p.m.	6,000 p.p.m.
7	2,500 p.p.m.	5,000 p.p.m.	7,500 p.p.m.
8	3,000 p.p.m.	6,000 p.p.m.	9,000 p.p.m.
9	3,500 p.p.m.	7,000 p.p.m.	10,500 p.p.m.
10	4,000 p.p.m.	8,000 p.p.m.	12,000 p.p.m.

The results are expressed in the following graphs which show the relative dry weight of the crop and the relative number of plants that germinated in comparison with the treatment receiving no alkali. In each case the control treatment is considered as 100 per cent and the others shown in percentage of the control. A line is drawn across each diagram at the height of the control in order that comparisons may be made more readily.

The solid black columns in the diagrams represent the relative dry weight of the crop and the cross-marked columns represent the relative number of plants that germinated.

#### DISCUSSION OF RESULTS

The results of the experiment are shown in detail in Figures 1 to 70. These show tests for 14 varieties of oats, 8 varieties of wheat, 3 varieties of barley, rye, 7 varieties of corn, 3 varieties of millet, 5 varieties of the sorghums, 8 types of forage legumes, 4 varieties of beans, 7 varieties of grass, 5 kinds of vegetables, sugar beets, buckwheat, hemp, flax, and rape. For each crop the more resistant varieties are shown first in the graphs.

On comparing the different varieties of oats, it is found that a considerable similarity exists in the resistance of the different varieties, Boswell Winter, Red Rust Proof, Black and White Tartar, and Colorado No. 9 in the order named being more non-resistant than the other varieties. The lower concentrations of salts usually produced stimulation in growth. This stimulation continued up to about 1,000 parts per million of the chlorides, about 2,000 parts per million of the carbonates, and about 3,000 parts per million of the sulfates. When the concentrations were made higher than the amounts given there was a rather rapid decline in the yield and number of plants germinated.

The varieties of wheat showed about the same conditions that



FIG. 1 OATS - DANISH

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

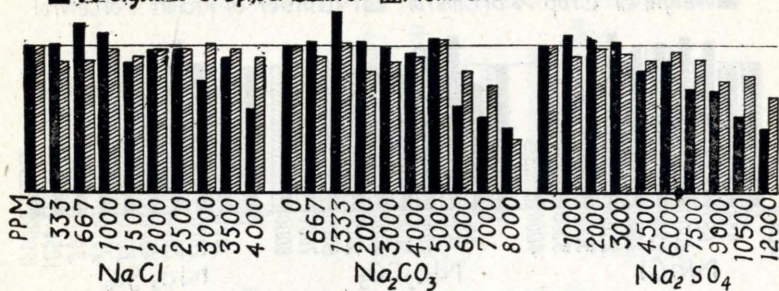


FIG. 2 OATS - GIANT YELLOW

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

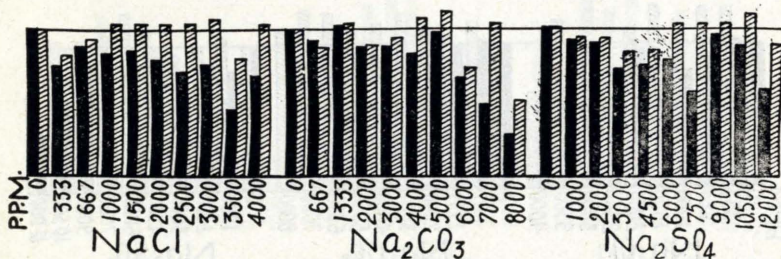


FIG. 3 OATS - MINNESOTA 26

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

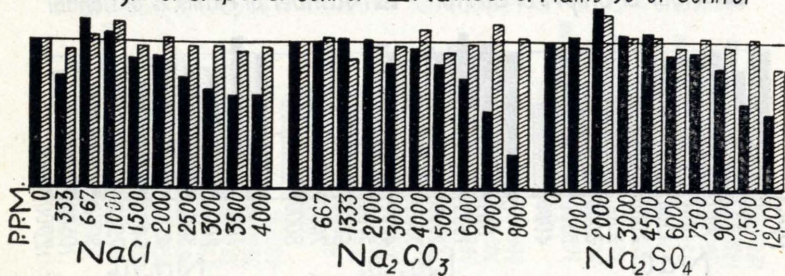


FIG. 4 OATS - BLACK AMERICAN

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

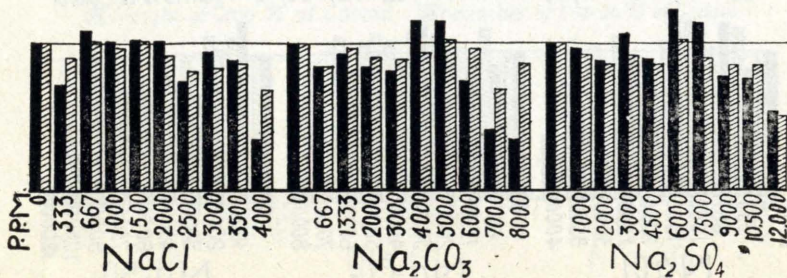




FIG. 5 OATS - KHERSON

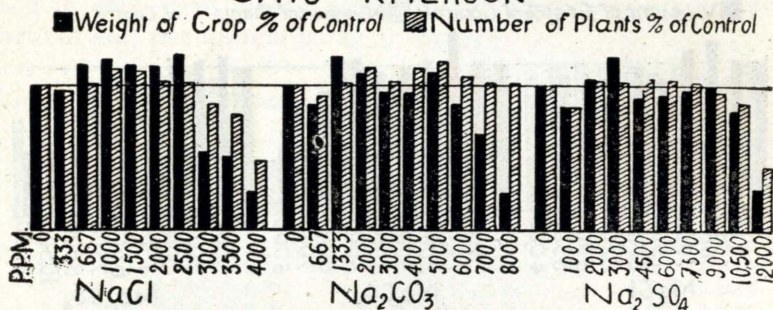


FIG. 6 OATS - BANNER

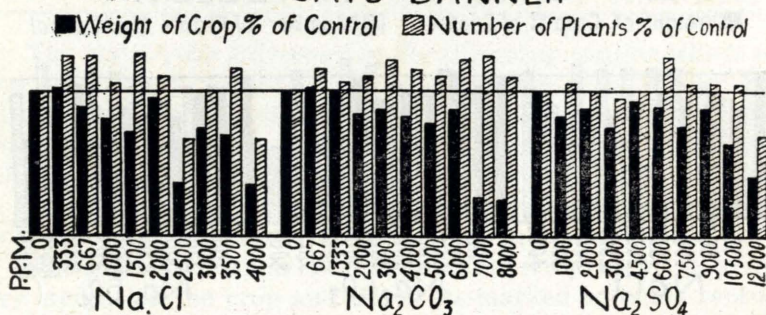


FIG. 7 OATS - LINCOLN

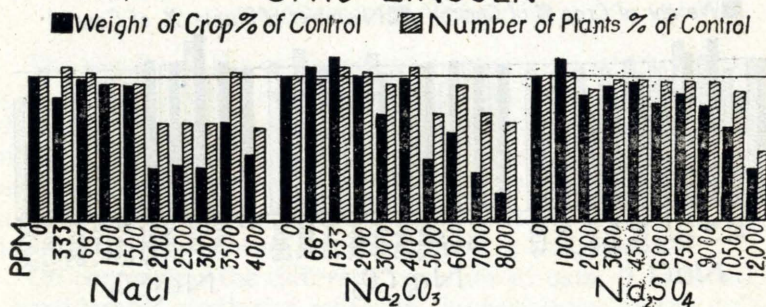
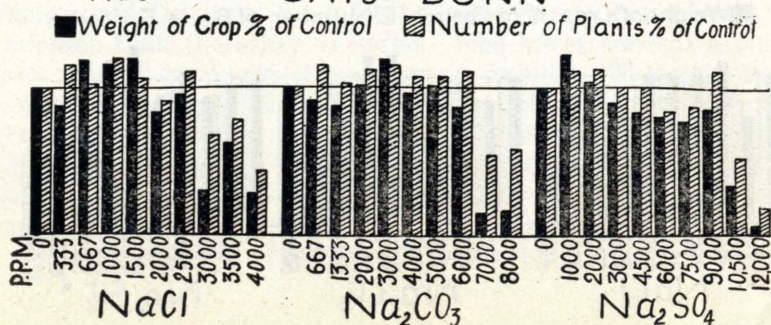


FIG. 8 OATS - DUNN





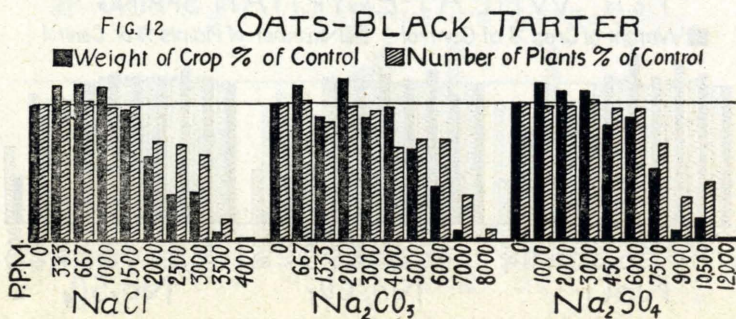
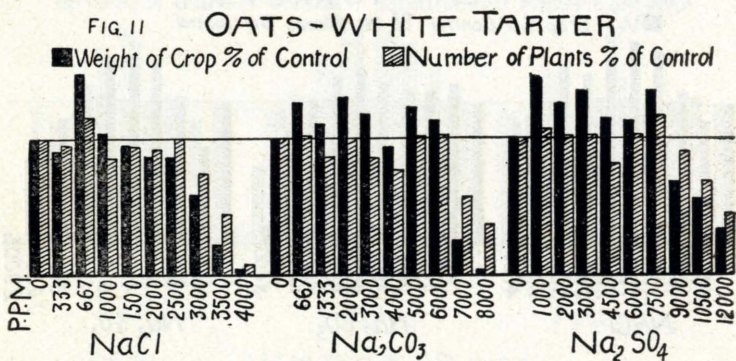
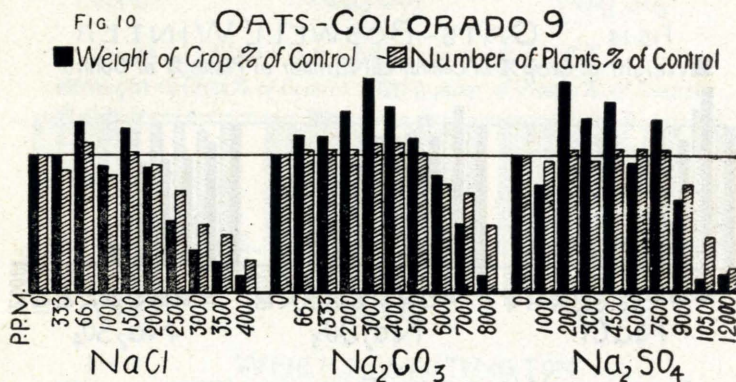
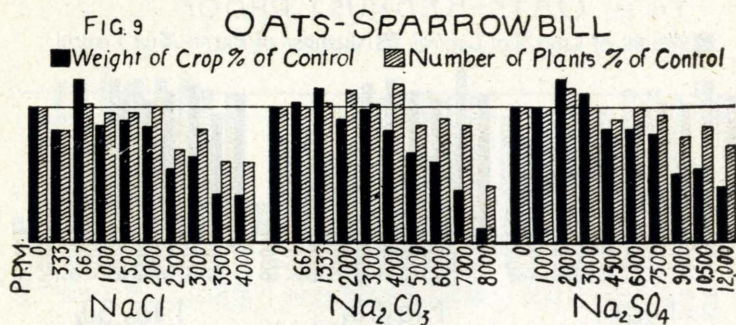




FIG. 13 OATS-RED RUST PROOF

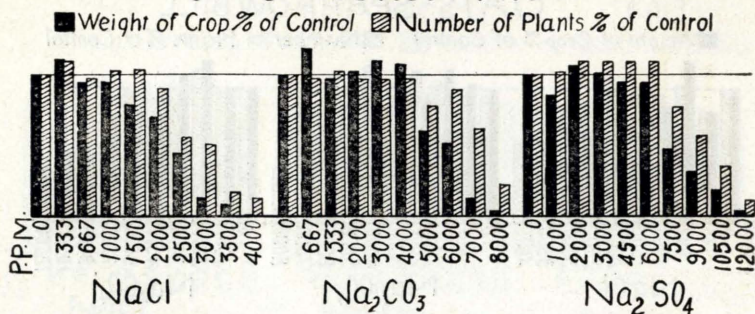


FIG. 14 OATS-BOSWELL WINTER

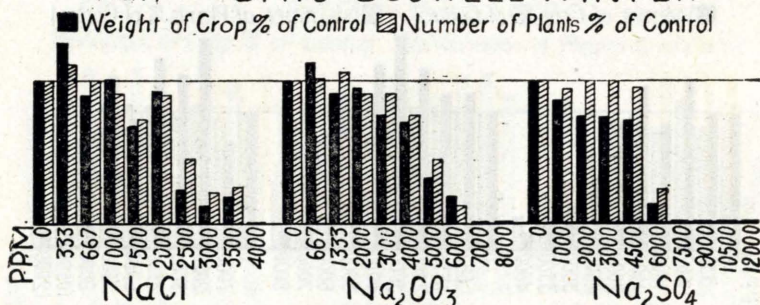


FIG. 15 WHEAT-TURKEY RED

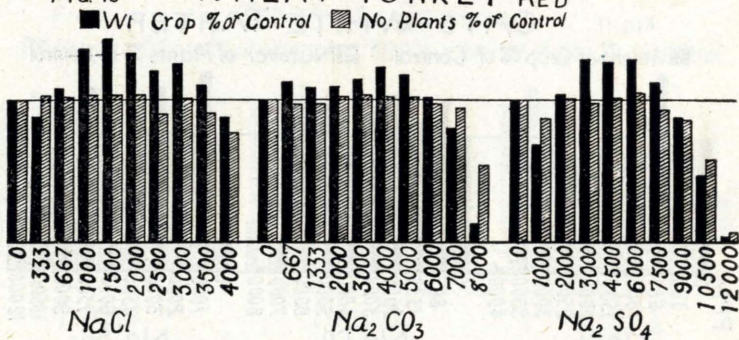


FIG. 16 WHEAT-EGYPTIAN SPRING

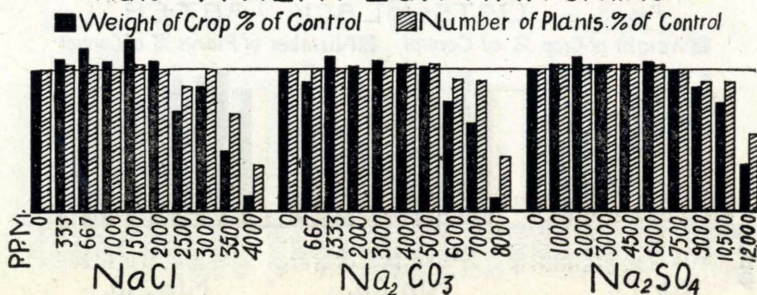




FIG. 17 WHEAT - FULTZ

■ Weight of Crop % of Control ▨ Number of Plants % of Control

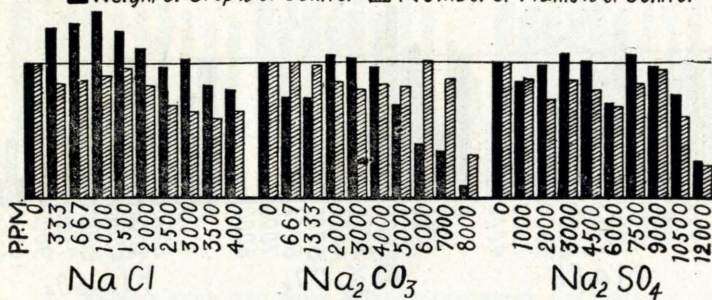


FIG. 18 WHEAT - MINNESOTA. 163

■ Weight of Crop % of Control ▨ Number of Plants % of Control

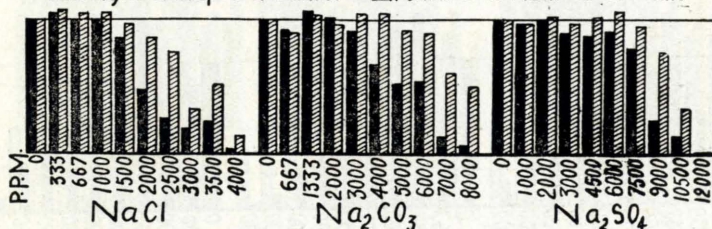


FIG. 19

WHEAT - WHITTINGTON

■ Weight of Crop % of Control ▨ Number of Plants % of Control

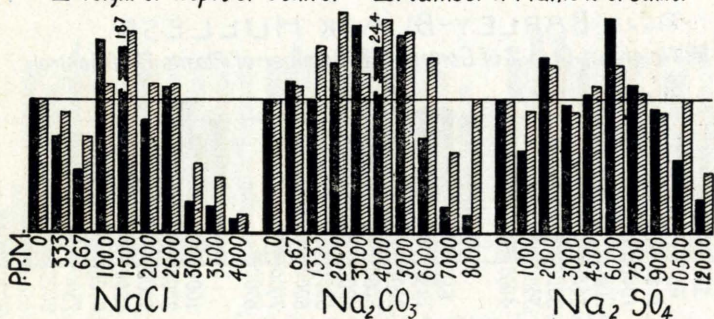


FIG. 20

WHEAT - BOBS

■ Weight of Crop % of Control ▨ Number of Plants % of Control

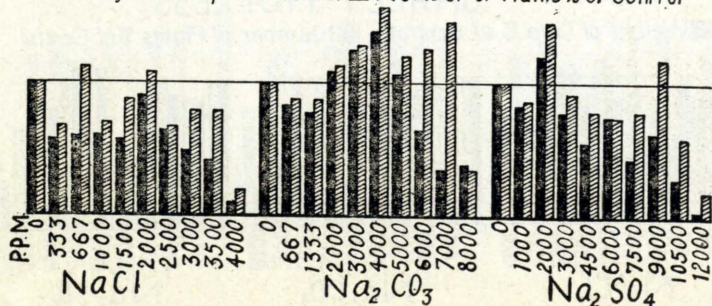




FIG. 21

## WHEAT-VELVET DON

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

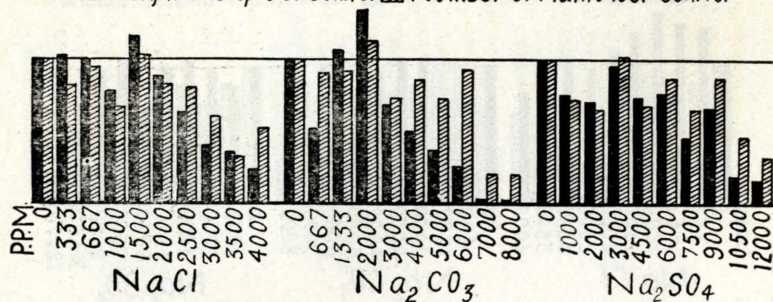


FIG. 22

## EINKORN

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

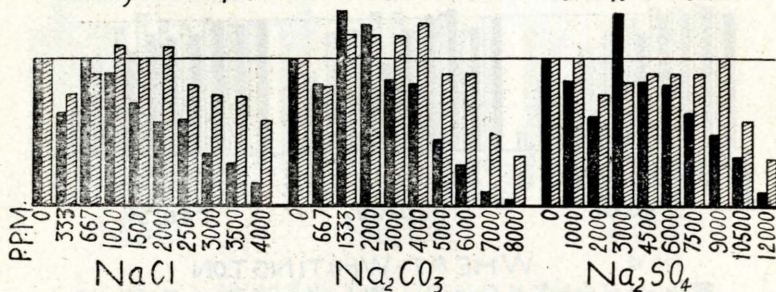


FIG. 23 BARLEY-BLACK HULLESS

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

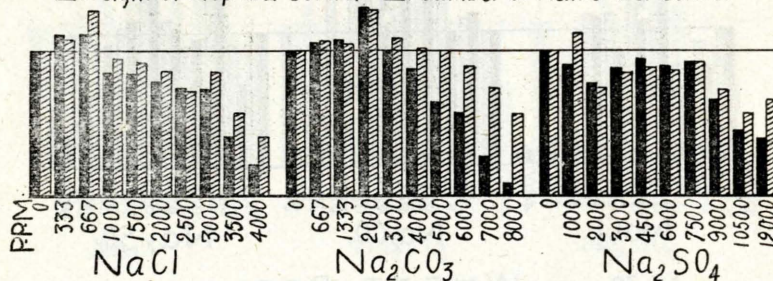


FIG. 24

## BARLEY-HULLESS

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

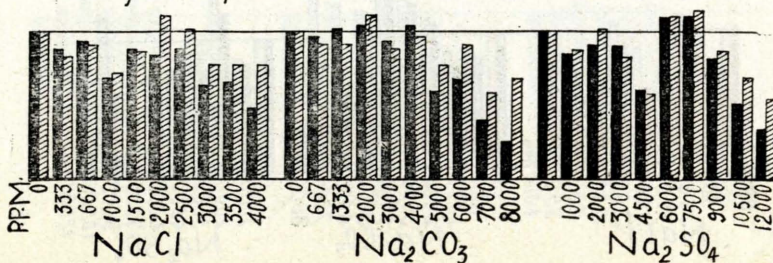




FIG 25 BARLEY-UTAH WINTER

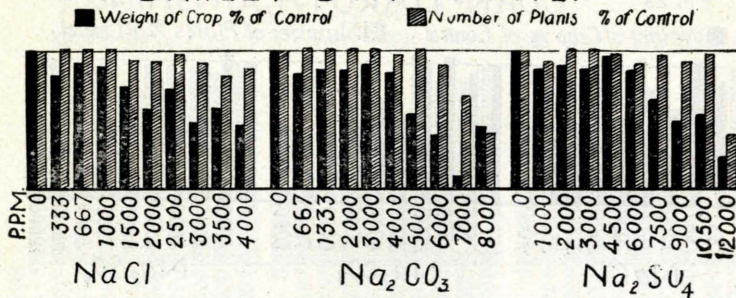


FIG 26

## R Y E

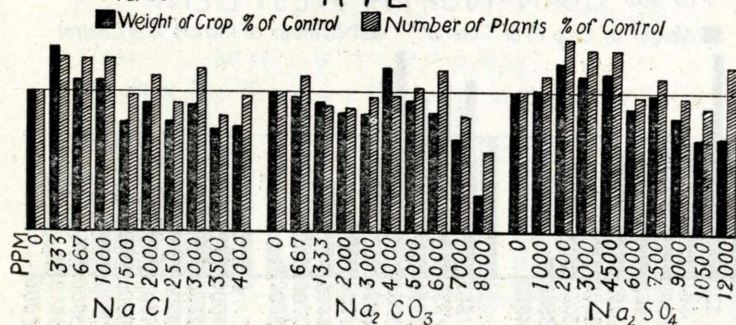


FIG 27

## CORN - HYBRID

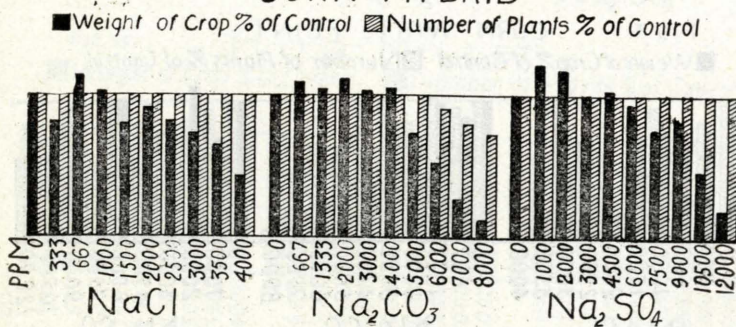
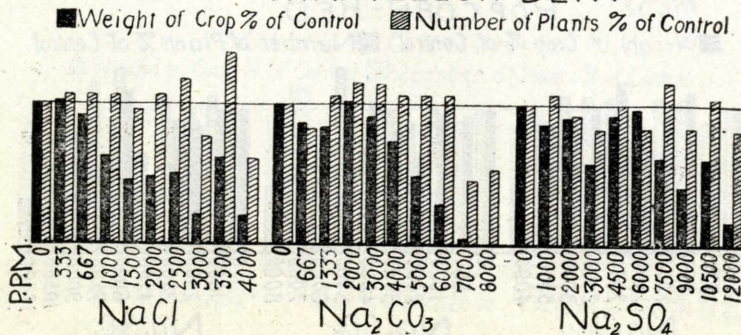


FIG 28

## CORN - YELLOW DENT





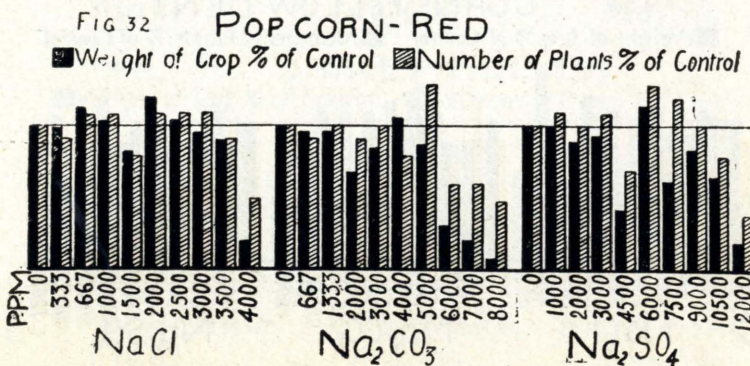
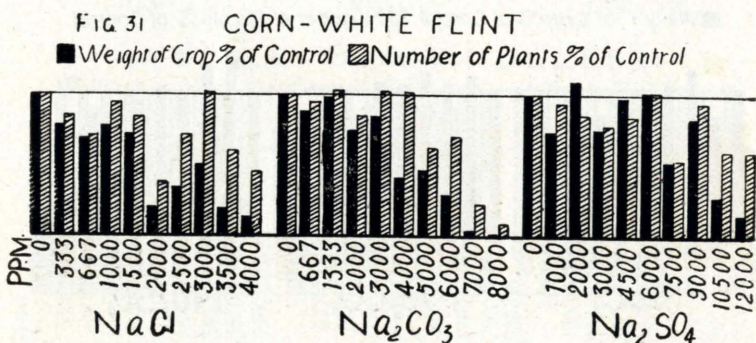
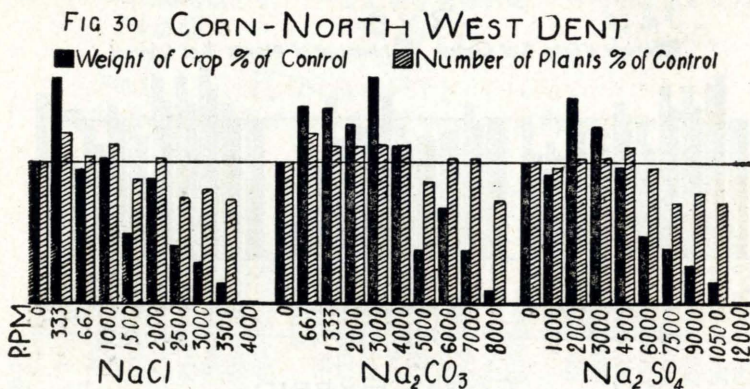
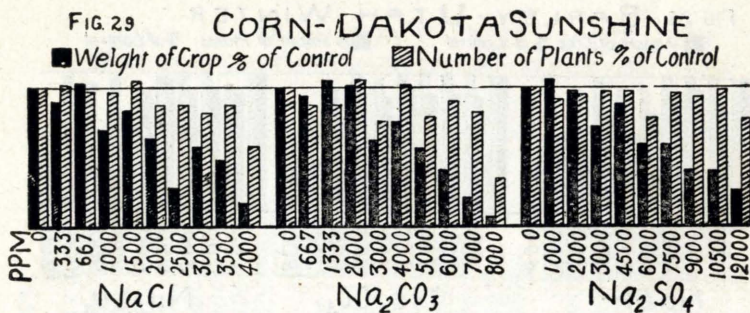




FIG 33

POP CORN WHITE RICE

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

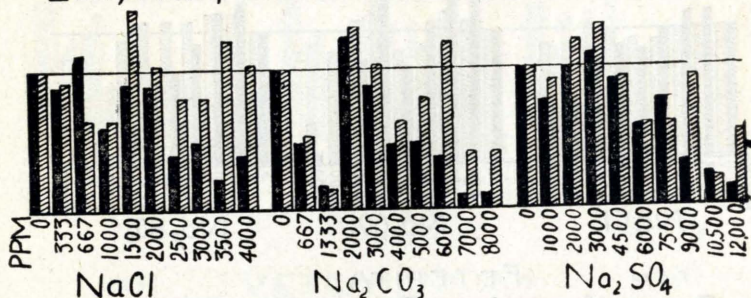


FIG 34

MILLET-JAPAN

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

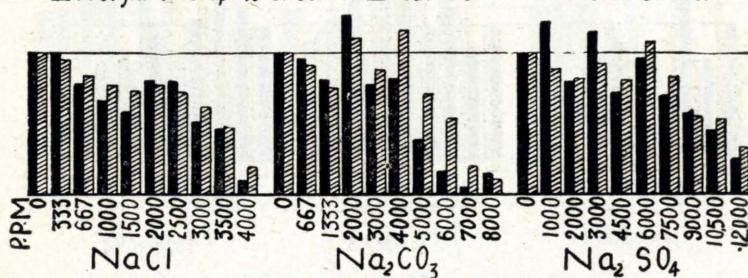


FIG 35

HOG-MILLET

■ Weight of Crop % of Control.    ▨ Number of Plants % of Control.

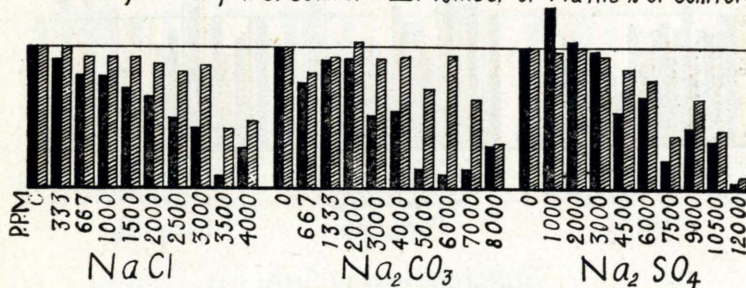


FIG 36

MILLET-GERMAN

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

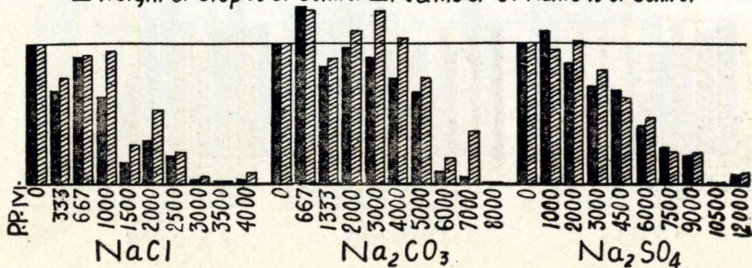




FIG 37

## SORGHUM-COLLIER'S

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

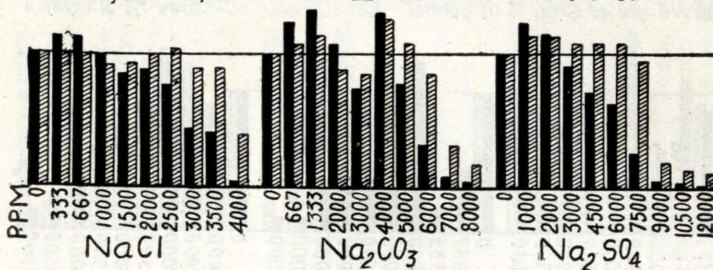


FIG 38

## FETERITA

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

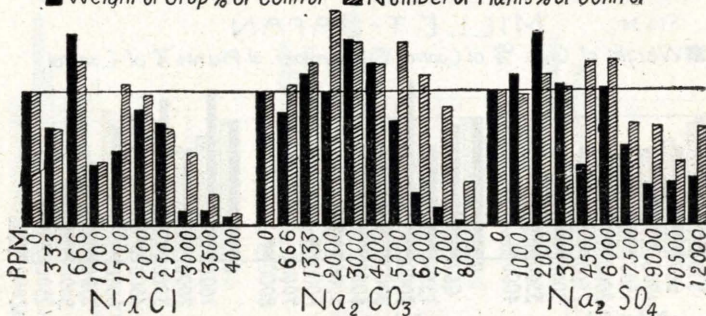
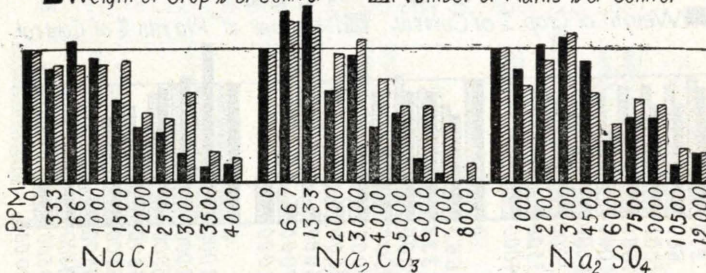


FIG 39

## CANE-EARLY AMBER

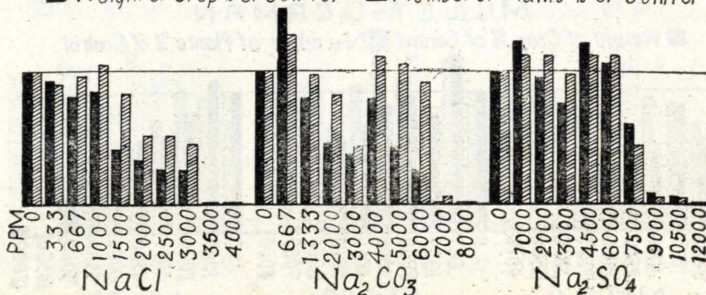
■ Weight of Crop % of Control    ▨ Number of Plants % of Control



FIG

## SORGHUM-NEW SHALLU

■ Weight of Crop % of Control    ▨ Number of Plants % of Control





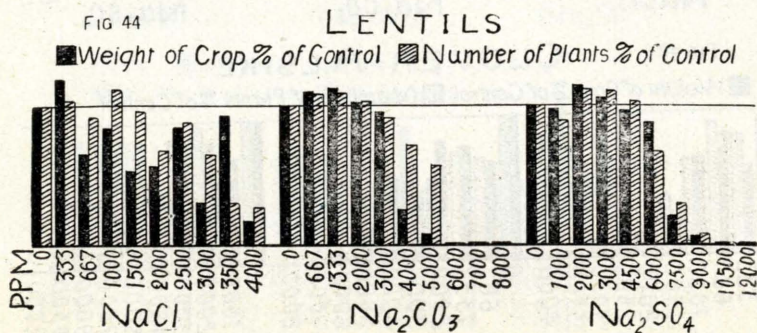
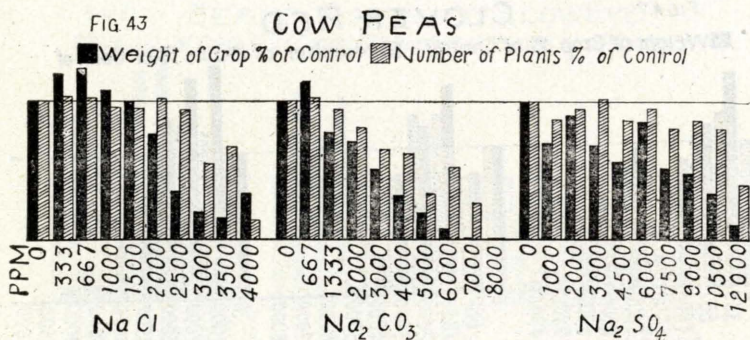
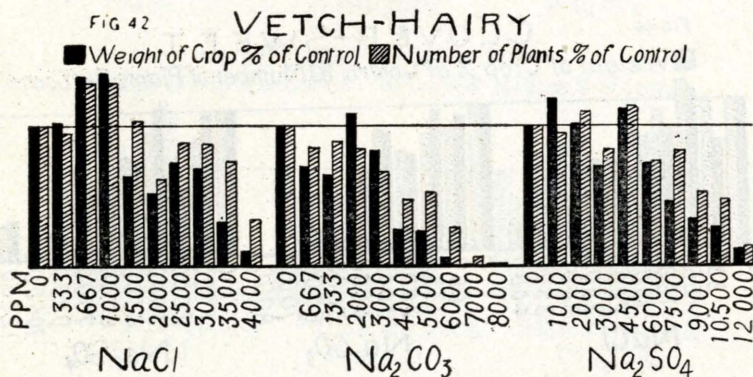
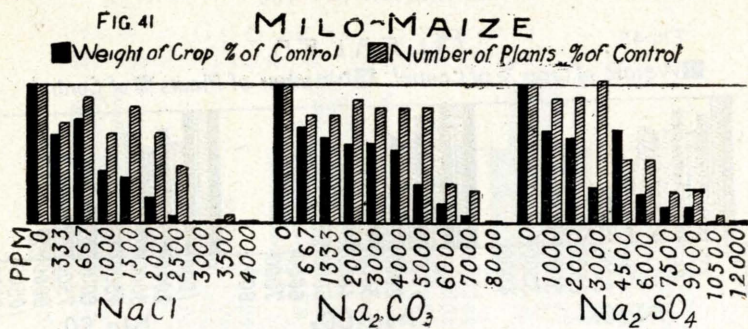




FIG. 45

## ALFALFA

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

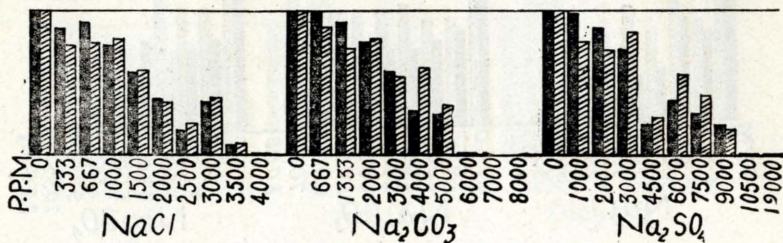


FIG. 46

## CLOVER-SWEET

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

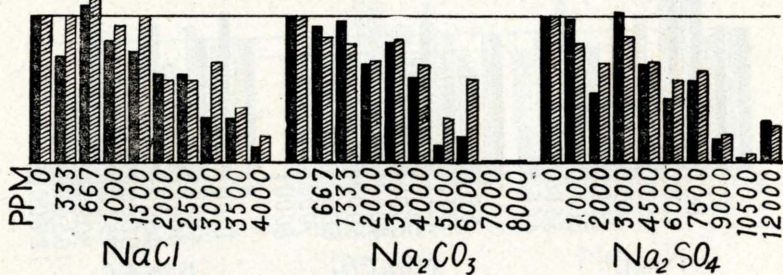


FIG. 47

## CLOVER-RED

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

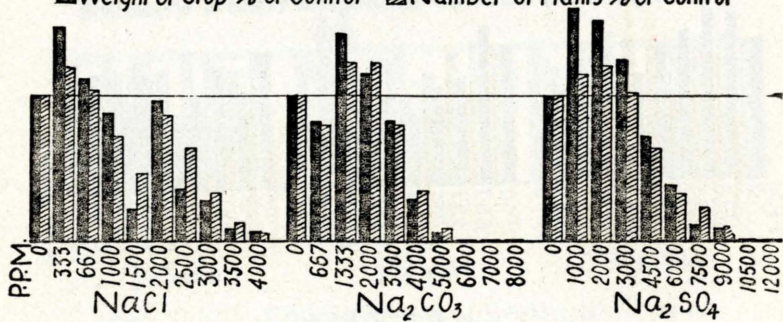
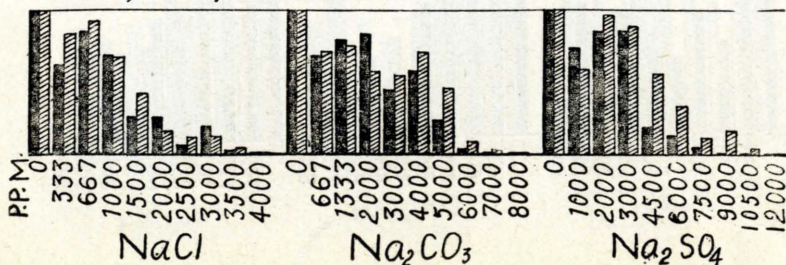


FIG. 48

## CLOVER-ALSIKE

■ Weight of Crop % of Control    ▨ Number of Plants % of Control



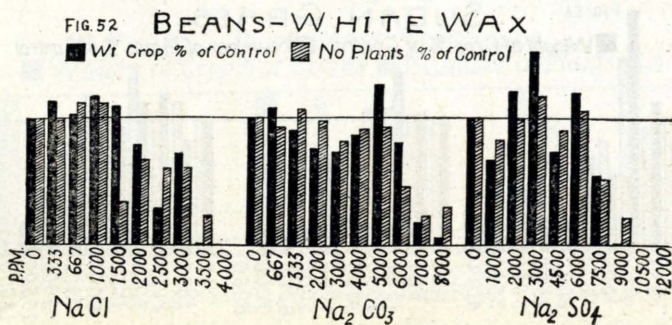
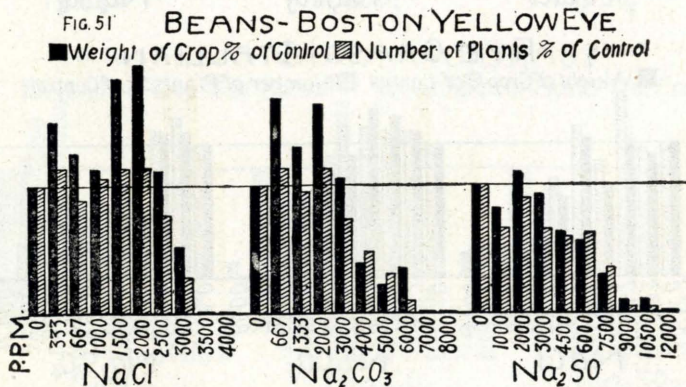
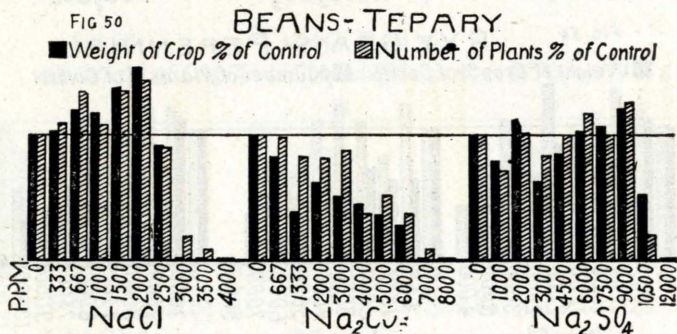
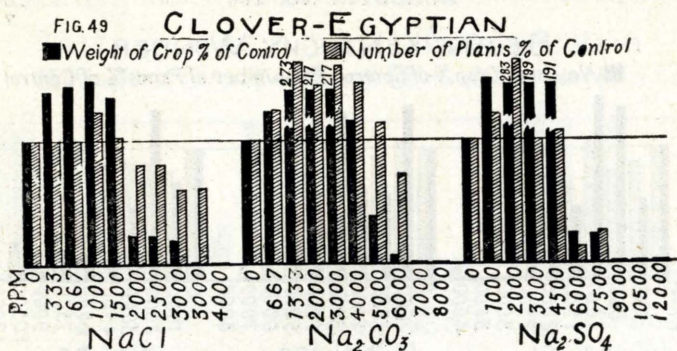




FIG. 53 BEANS-KENTUCKY WONDER

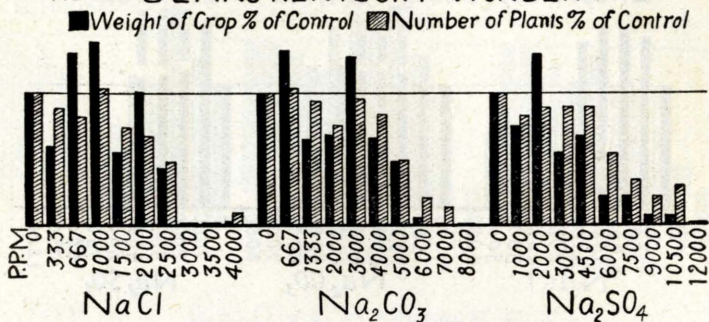


FIG. 54

## RYE GRASS- PERENNIAL

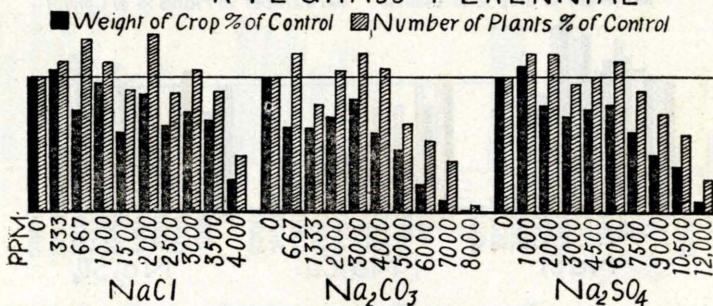


FIG. 55

## RYE GRASS- ITALIAN

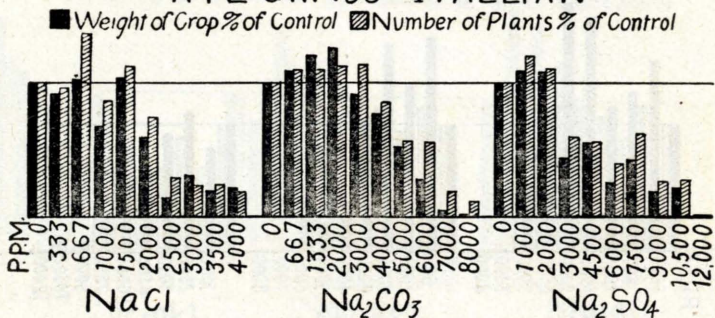


FIG. 56

## SUDAN GRASS

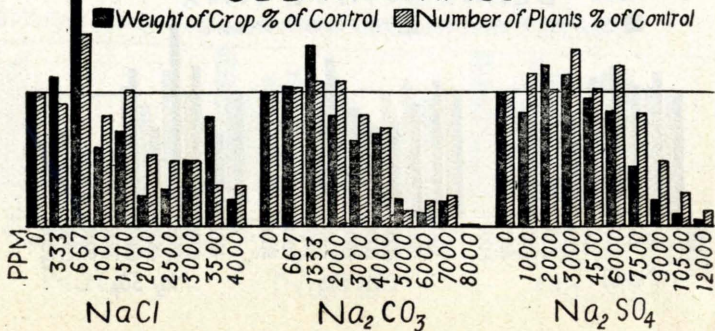




FIG. 57

## MEADOW FESCUE

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

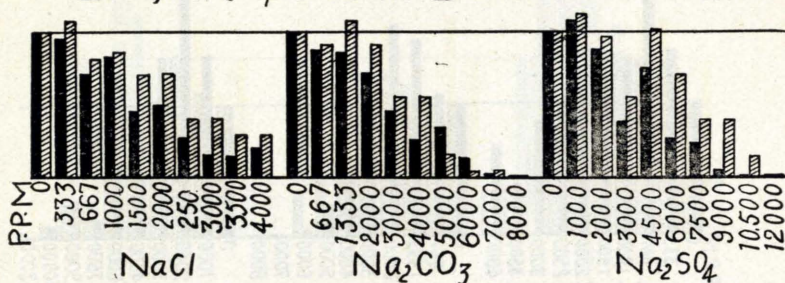


FIG. 58

## TIMOTHY

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

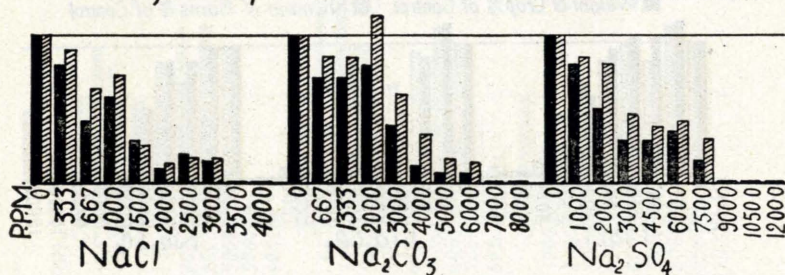


FIG. 59

## ORCHARD GRASS

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

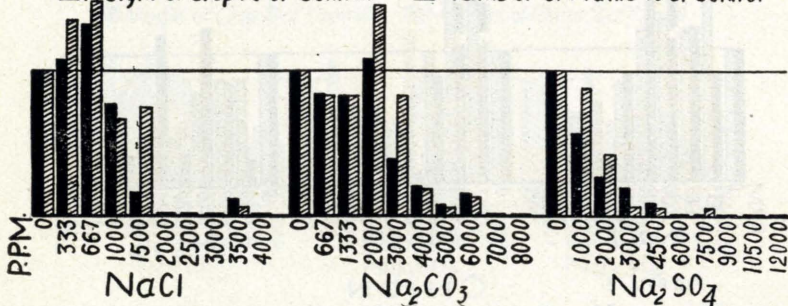


FIG. 60

## BLUE GRASS - KENTUCKY

■ Weight of Crop % of Control    ▨ Number of Plants % of Control

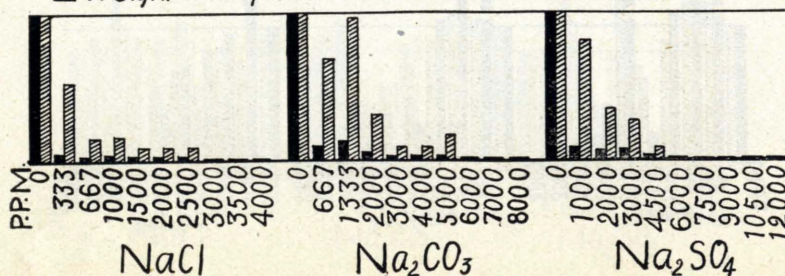




Fig. 61

## RADISH

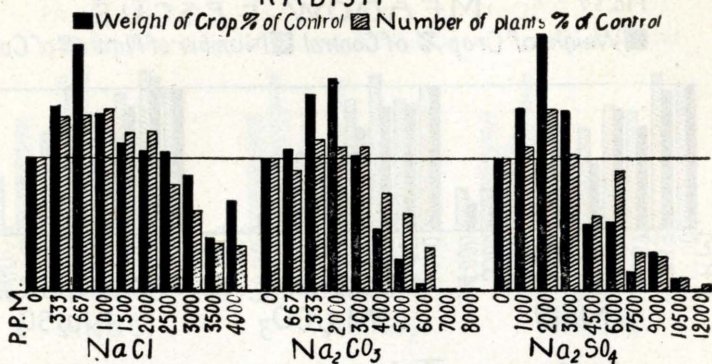


FIG. 62

## MUSK MELLON

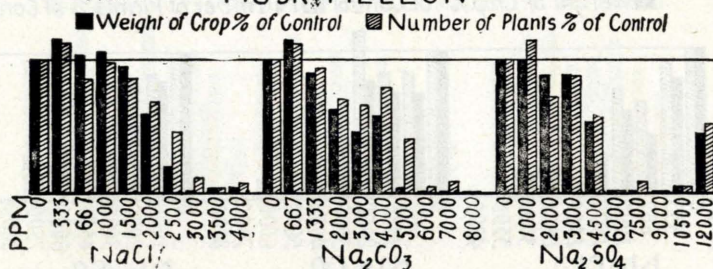


FIG. 63

## TURNIP

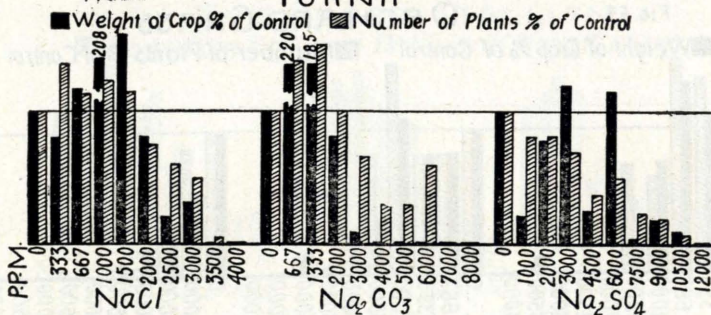
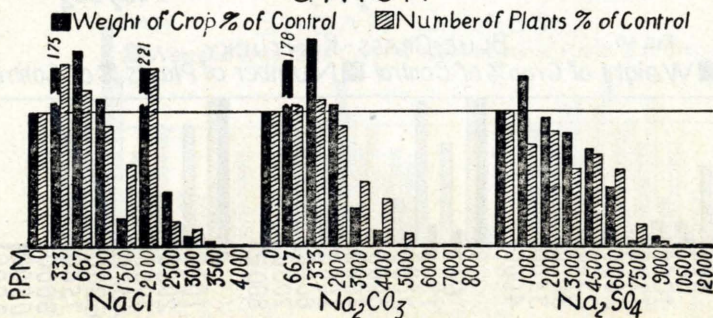
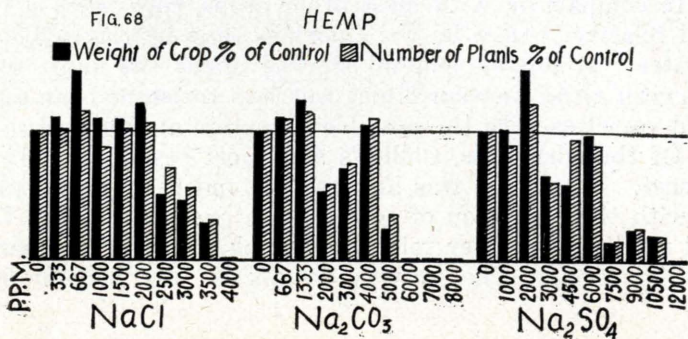
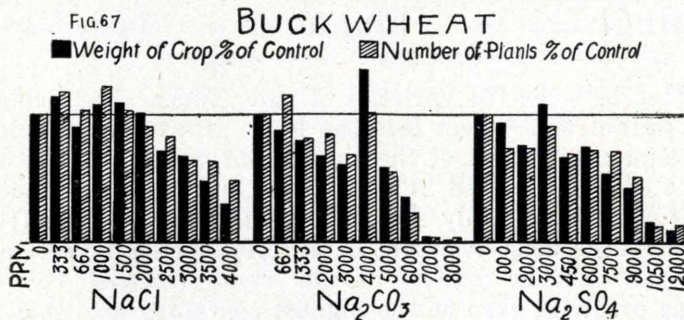
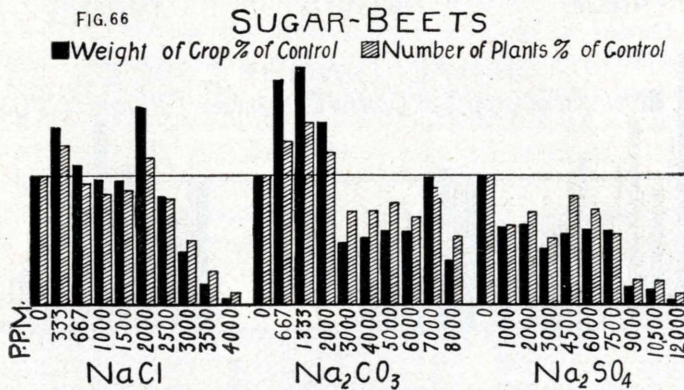
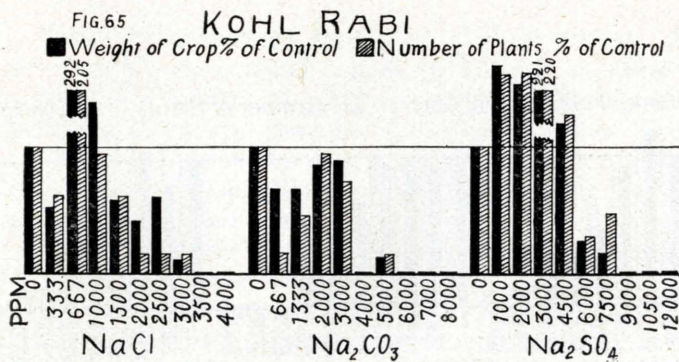


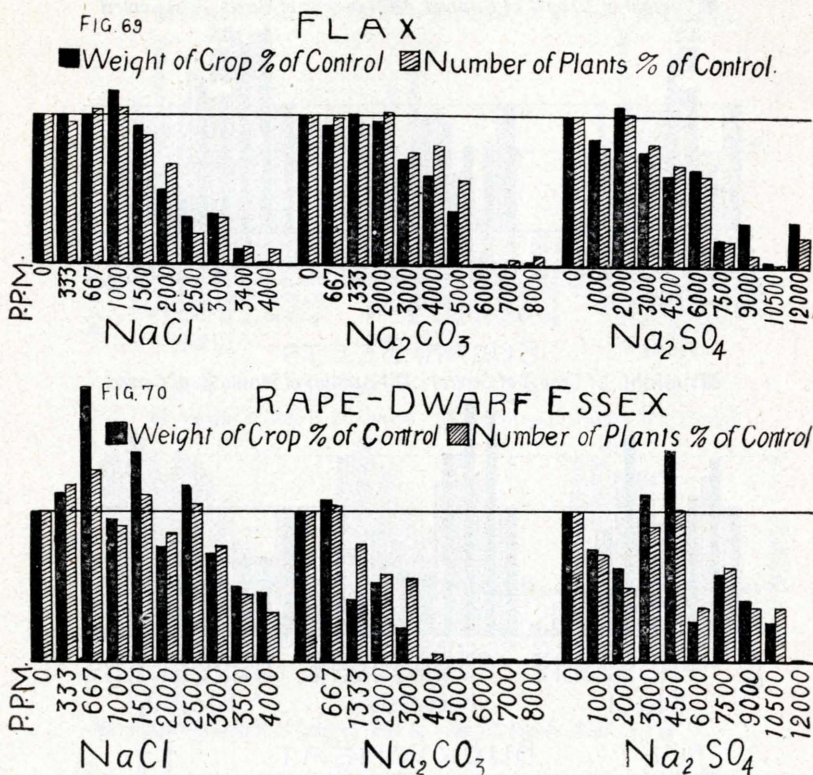
FIG. 64

## ONION









were noted between the varieties of oats, Turkey Red being the most resistant and Velvet Don the least. Einkorn was slightly less resistant than most of the varieties of wheat. Of the three varieties of barley tested, Black Hullless was most resistant and Utah Winter least. Only one variety of rye was tested; this was among the most resistant of all crops under investigation. Corn began to show toxicity at low concentrations but some crop was produced even at the highest concentrations that were used. In comparison with most other crops, corn seemed to be effected relatively more by the chlorides than by the carbonates or sulfates. Millets in general showed about the same resistance as corn altho German Millet was less resistant than any of the corn varieties with the possible exception of White Rice Pop Corn. Of the sorghums, Collier's was most resistant and Milo Maze least. Milo Maze was among the most sensitive plants tested with the exception of some of the grasses. Hairy Vetch showed relatively greater tolerance for chlorides in comparison with other crops. The growth of alfalfa was prohibited by



lower concentrations than that of sweet clover. Neither of these crops shows unusual resistance in the seedling stage. The larger seeded plants in general seemed to be able to germinate better in alkali land than the small seeded ones. There are, however, some exceptions to this rule. The growth of beans was stimulated by small quantities of alkali altho growth was entirely prohibited at the higher concentrations.

Of the grasses under investigation, the rye grasses were more tolerant than other varieties. Kentucky Blue Grass was the least tolerant of all crops under investigation. Orchard Grass was only slightly more resistant. Rape showed much greater resistance for the chlorides than for the carbonates or sulfates. If chloride was used as the indicator rape would be placed among the most resistant crops, whereas if the carbonates were used it would be considered one of the most tender. Sugar beets on the other hand were stimulated by lower concentrations of carbonates but were effected very deliteriously by the sulfates and somewhat less by the chlorides. Kohl Rabi showed great resistance for the lower concentrations of sulfates but was decidedly effected by even the lower concentrations of carbonates and practically no growth was made in concentrations higher than 3,000 parts per million.

Taken all together these results show that salts added to the soil in higher concentrations than 4,000 parts per million of chlorides, 8,000 parts per million of carbonates, and 12,000 parts per million of sulfates are entirely too high to allow a satisfactory yield of the ordinary crops. These figures would have to be modified if they were obtained from analysis of alkali soil since the relation between salts such as chlorides and carbonates is not the same for "salts added" and "salts extracted."

As crops for alkali land, the cereals would doubtless be among the best of those investigated and the grasses among the poorest.

Of the forage crops, vetches, cow peas, alfalfa, and sweet clover are doubtless superior on alkali land to the grasses. Timothy and Alsike Clover, which are recognized as good crops for wet land, are shown to be relatively non-resistant and probably should not be included among the forage crops for wet alkali land.